УДК 628.316

Matthias Barjenbruch, doctor of engineering, professor
Technische Universität Berlin, Berlin, Germany

ADVANCED WASTEWATER TREATMENT

Introduction

Wastewater treatment plants (WWTP) mainly remove organic compounds (COD, BOD5) but often nitrogen (N) and phosphorus (P), as essential nutrient parameters also are legally limited to protect surface waters from eutrophication (EC Directive 91/271 / EEC).

The term "advanced wastewater treatment" has changed over the years. Whereas earlier the focus was on the elimination of the nutrients phosphorus and nitrogen as well as the suspended matter removal, nowadays the focus is on the following topics:

1) further suspended matter removal;
2) conversion or elimination of N and P beyond the requirements of the wastewater server order;
3) elimination of refractory substances (residual COD, etc.);
4) wastewater disinfection to reduce pathogenic germs;
5) elimination of micro-pollutants (medicines, endocrine substances, personal care products, pesticides, etc.);
6) removal of micro-plastic from cosmetics, etc.;
7) nanoparticles (currently still in the focus of research).

Advanced removal of suspended solids

For further particle removal and P-elimination, wastewater filtration is applied, which is classified according to various criteria (structure of the filter medium, flow direction, backwashing cycle, etc.). Worksheet DWA A 203 (2019) and DIN EN 12255-16 (1999). You can distinguish between surface filtration (microsieves, cloth filters, shallow bed filters (Depth approx. 60 cm) with the filtration effect on the surface) and deep bed filtration: single or multi-layer filter (Depth approx. 2.0 m) operated discontinuously or continuously, with the filter effect in the depth of the bed (Figure 1).

Wastewater filtration ensures a very low level of effluent concentrations. Practice data show a variation of effluent COD between 10 and 25 mg/l. Flocculation filter offer effluent values below 1 mg TSS/l and Phosphorus effluent concentration within a range of 0.06–0.50 mg/l.

Wastewater disinfection

Municipal wastewater can contain a wide variety of pathogens (viruses, bacteria, protozoa, fungi, worms). People can come into contact by bathing in rivers or lakes or by the consumption of wastewater-influenced drinking water. This can cause diseases such as diarrhea, nausea, fever, skin diseases. Wastewater disinfection should minimize the risk of infection. Technologies on a physical or chemical basis are available for the disinfection of wastewater (DWA M 205 (2012)):

– physical procedure: UV irradiation, membrane filtration and thermal treatment (use for partial flows, e.g. hospital);

– chemical processes: ozone, peracetic acid or hydrogen peroxide. Chlorination is not used in Germany for wastewater treatment due to the possible formation of toxic chloramines and CHCs.

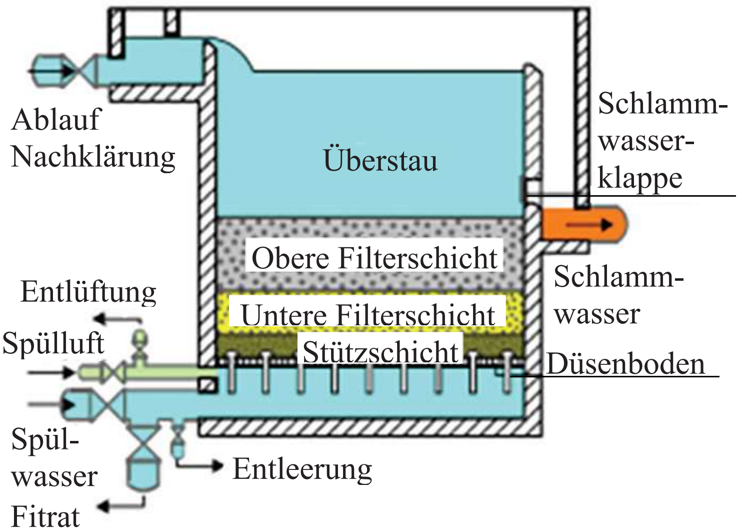

Figure 1 – Deep bed filtration

In the German sewage practice predominantly the UV irradiation is applied (Figure 2). Most effectively, the genetic information of the microorganisms is damaged by radiation having a wavelength of 254 nm. The main influencing factors are the mean UV dose 300–450 [J/m^2] and the transmission [%/cm] of the wastewater. In order to ensure that as many cells as possible receive the same UV irradiation in the irradiation tank, an ideal plug flow with good cross-mixing is important.

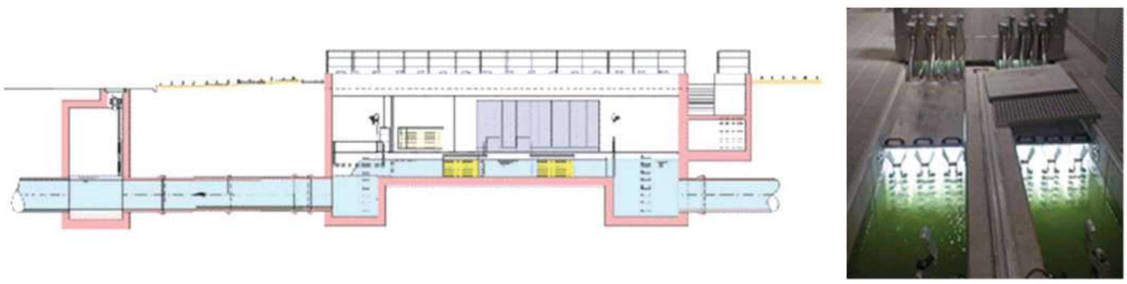

Figure 2 – Example of an UV irradiation

Micro-pollutants

Micro-pollutants are inorganic and organic substances which are observed in the concentration of a few μg/l or less in all types of water. They are characterized by a predominantly poor degradability in the conventional treatment process. In addition, they are in the focus due to their bioavailability as well as their possible accumulation and relevance from a toxicity point of view for the water cycle. The anthropogenic micro-pollutants include, in particular, human pharmaceuticals, industrial chemicals, personal care products, detergent ingredients and veterinary pharmaceuticals as well as pesticides, and feed additives. Currently, the elimination of micro-pollutants is not yet required by law.

Accordingly, the current status of municipal sewage treatment plants must be upgraded with additional technologies to remove micro-pollutants Particularly suitable are processes which have already been used for other water treatment applications. Which includes:

1) chemical oxidation: z. Ozonation, AOPs, UV irradiation (combinations);

2) sorption on special adsorbents, e.g. as granular or powdered activated carbon;

3) separation by means of the finest membranes, e.g. nanofiltration, reverse osmosis (appears to be unsuitable because of the high energy requirements and the large to be disposed of concentrate streams).

For the ozonation is needed: the ozone generation, purified air or pure oxygen (storage tank), the entry device, the reaction chamber (t_R about 10–30 min) an ozone treatment and a post-treatment with (Bio) filter in which the formed biodegradable oxidation byproducts can be degraded.

At KA Regensdorf (Switzerland), the most comprehensive investigations to date of the ozonation of the wastewater treatment plant have been carried out. At the highest ozone dose of 1.16 g O_3/g DOC, elimination was above 95 % for all substances tested, except for some atrazine derivatives and some X-ray contrast media [1].

The principle of activated carbon adsorption is based essentially on the physical adsorption by electrostatic interactions between the molecule to be adsorbed (predominantly non-polar, organic substances) and the activated carbon surface. Granulated or powdered activated carbon (PAC) can be used. For the removal of micro-pollutants, the downstream PAC dosage with contact reactor is used. The PAC is metered into the contact reactor, thoroughly mixed in, then sedimented and returned to the contact reactor. The contact time should be chosen so that an optimum for the elimination of the substances to be removed is achieved. In semi-technical experiments, a contact time of 0.5 h has proved to be favorable for the removal of trace gases [1].

Reference

1. Barjenbruch, M. Möglichkeiten der Elimination von anthropogenen Spurenstoffen auf kommunalen Kläranlagen / M. Barjenbruch, W. Firk, A. Peter-Fröhlich // Korrespondenz Abwasser. Abfall. – 2014. – № 61. – S. 861–875.